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SCALP HEALTH AND THE ROLE OF  
THE SCALP BARRIER IN DANDRUFF  
AND SEBORRHEIC DERMATITIS

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# Insights on the Impact of Scalp Barrier Condition on Hair Health

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## ABSTRACT

Scalp health is essential for healthy hair growth and may be affected by intrinsic or extrinsic factors. Reactive oxygens species are key contributors to aging and can have a detrimental impact on scalp health. Oxidative stress on the scalp is thought to be a factor in developing dandruff. We present consensus statements on scalp barrier health and its effects on hair through a systematic literature search and expert panel discussion. Three dermatologists with extensive experience in hair were selected to form a panel that formulated consensus statements that would best capture the current understanding of scalp health. The consensus statements developed and presented in this manuscript highlight the current literature and broader discussion surrounding scalp health and its impact on hair and dandruff. It also highlights the often-overlooked effects of scalp conditions on hair health and growth. Through our research, we found that there has been minimal emphasis on scalp health in the setting of dandruff, with most studies focusing on other inflammatory diseases such as psoriasis and atopic dermatitis. Here, we review the clinical importance of focusing on the impact of the scalp barrier condition on hair health.

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## INTRODUCTION

Research has shown that scalp and hair health are connected, but the link is not yet fully understood or characterized. Hair growth begins within the hair follicle, about 4 mm deep in the skin.<sup>1</sup> The cells proliferate in the bulb of the follicle and produce a nascent hair fiber that continues to grow to the scalp surface.<sup>1</sup> As the hair extends to the skin surface, the hair fiber undergoes keratinization.<sup>1</sup> At the same time, the skin microenvironment surrounding each follicle propagates signals to the hair fiber, thereby impacting the quality and character of the resultant hair.<sup>1</sup> The hair follicle undergoes cycles of growth (anagen), apoptosis-mediated regression (catagen), and relative quiescence (telogen).<sup>1,2</sup> During its life cycle, the hair follicle is highly sensitive to surrounding growth factors, cytokines, neuropeptides, and hormones, often produced by the hair follicle itself.<sup>2</sup> Thus, scalp and hair follicle health is critical to hair care. Factors affecting scalp health may go into four categories: hair follicle health, inflammatory conditions,

environmental/exogenous factors, and scalp microbiome.<sup>2</sup> While overall scalp health has yet to be understood, inflammatory scalp conditions such as psoriasis, dandruff/seborrheic dermatitis (D/SD), atopic dermatitis (AD), as well as fungal scalp conditions such as pityriasis versicolor (PV), and tinea capitis have been extensively studied.<sup>1</sup> It has long been known that inflammatory scalp conditions negatively impact hair growth; however, the characterization of overall scalp health and its impact on hair growth has been less evident in the literature. There is little information about scalp care in scalp-related inflammatory conditions. Furthermore, exogenous agents such as chemotherapy, smoking, ultraviolet radiation, and chemical insults from hair products and pollutants, amongst others, can negatively impact hair growth.<sup>3</sup> Contact dermatitis from fragrances, hair colorants, or treatments containing formaldehyde and formaldehyde releasers may also result in an irritated scalp and inflammation, leading to hair shedding.<sup>3</sup> Exogenous factors such as psychological and physical stressors have also been reported to impact the hair growth cycle, likely through modu-

lation of the body's hormones and inflammatory balance.<sup>3</sup> The scalp environment, rich in sebaceous glands, supports a diverse microbiome. These microbes likely play a significant role in scalp health and hair growth. In conditions such as psoriasis and D/SD, *Malassezia* is present in abnormally high amounts.<sup>3</sup> Studies have shown that *Malassezia* metabolism produces reactive oxygen species (ROS), which contribute to scalp skin and hair oxidative damage.<sup>4-6</sup>

Healthy hair growth is rooted in scalp health and maintaining a healthy scalp barrier. Evidence supports a cause-and-effect linkage between scalp condition and resultant hair condition. Thus, hair health is inherently linked to the health of the scalp environment. Here, we present five consensus statements summarizing the current understanding of the scalp barrier and hair health through the lens of expert dermatologists.

## METHODS

A panel of 3 expert dermatologists met on July 20<sup>th</sup>, 2022, in Vancouver, Canada, to discuss the outcomes of a systematic literature review that aimed to identify the challenges in scalp barrier health and provide insights and recommendations to promote healthy hair and scalp. The systematic literature review included guideline articles, consensus papers, clinical trials, comparative trials, open-label studies, and clinical or other research publications from 2010 to 2022. The scope of the literature search was scalp health, skincare, and the role of ceramides. Two reviewers (AA and HA) evaluated and assembled the results to yield 84 scalp-related papers (59 clinical studies and 25 reviews). Using the literature review, five statements were formed by the panel to summarize challenges in promoting scalp barrier and hair health and highlight the importance of ceramide-containing products in scalp care. The statements guided the expert panel's discussion of current scalp health literature to raise awareness about this important issue.

## RESULTS

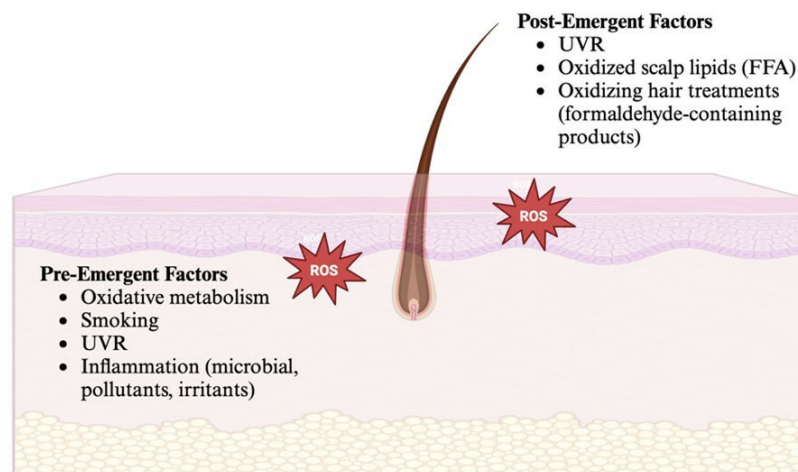
**Statement 1:** *There is evidence for a cause-and-effect link between the condition of the scalp and hair health. Scalp conditions such as psoriasis, D/SD, AD, contact/irritant dermatitis, and tinea capitis, among others, may lead to unhealthy hair.*

Like the skin, the scalp provides an essential barrier between the body and its environment, acting as a physical barrier that restricts water loss, prevents entry of external irritants, and regulates tissue homeostasis by balancing the immune response to endogenous and exogenous factors.<sup>7</sup> Psoriasis results from an inflammatory imbalance in the skin and typically presents on the scalp as erythematous, white, and flaking plaques. Hair that grows on the psoriasis-affected scalp has been shown to be thinner and smaller in diameter with a rougher surface.<sup>4</sup> Clinically, patients with psoriasis often report significant hair loss, which correlates with studies that show increased telogen and decreased anagen hair phases in those patients.<sup>8</sup> Similarly, hair from patients with AD and D/SD has also been shown to have increased roughness with thicker cuticular edges.<sup>4</sup> The rough hair texture contributes to a reduction in hair shine in these conditions. Inflammation caused by fungal infections in tinea capitis leads to alterations in hair morphology (corkscrew, comma, or zigzag hairs).<sup>4</sup> Inflammation may be due to contact dermatitis from shampoos, hair dyes, keratin treatments, or hair accessories, and it may lead to hair loss, likely secondary to the chronic inflammation of the scalp.<sup>3</sup> Hair products containing formaldehyde and formaldehyde releasers have been suggested to trigger the development of psoriasiform dermatitis.<sup>9</sup> Thus, scalp inflammation is intrinsically tied to hair health, underscoring the importance of addressing the scalp's condition to promote hair health.

**Statement 2:** *Oxidative stress plays a role in the etiology of scalp conditions such as D/SD, contact dermatitis, psoriasis, and normal aging. Oxidative stress in the scalp may alter the normal hair keratinization process, contribute to brittle hair, and impede normal fiber anchorage.*

Oxidative stress has been thought to affect overall aging and health significantly. ROS, the primary driver of oxidative stress, damages the scalp's structural proteins and DNA, ultimately harming the hair.<sup>4</sup> The body has built-in endogenous defense mechanisms in the form of antioxidant enzymes such as superoxide dismutase, glutathione peroxidase, and catalase, as well as anti-oxidative molecules such as vitamin E, vitamin C, glutathione, and ubiquinone that can neutralize ROS and protect the body and its structures.<sup>4</sup> The condition of a hair fiber depends on a combination of pre- and post-emergent factors.<sup>4</sup> Pre-emergent factors include oxidative factors such as smoking, ultraviolet (UV) radiation, microbe-induced inflammation, disease-induced inflammation, or oxidized scalp lipids. Post-emergent fiber stressors include chemical insults from oxidizing hair colorants, pollutants, and UV radiation (Figure 1).<sup>4</sup> Free radical-mediated lipid peroxidation is used as a biomarker of oxidative stress and is commonly detected in conditions such as D/SD, psoriasis,

**FIGURE 1. Oxidative stress factors on pre-emergent and post-emergent hairs.**<sup>4</sup> Oxidative stress can affect the hair pre-emergently, on the scalp, or post-emergently, on the surface of the head. Factors affecting the scalp microenvironment hair include oxidative metabolism, smoking, local or systemic inflammation, and UVR. Post-emergently, UVR, oxidized scalp lipids, and oxidizing hair treatments such as formaldehyde-containing products may also damage the hair.



Ultraviolet radiation (UVR)

and AD. Interestingly, in D/SD, the *Malassezia* species, a pathogenic driver of the condition, has also been shown to cause oxidative stress in a dose-dependent way.<sup>4</sup> In a 24-week randomized, double-blind, placebo-controlled clinical trial using scalp application of functional antioxidants and barrier-enhancing cosmetic ingredients, there was a significant reduction in hair shedding and increased perceived hair fullness.<sup>10</sup> Antioxidant ingredients used in this study included caffeine and niacinamide.<sup>10</sup> Thus, further research is warranted to develop barrier-enhancing products that promote scalp and hair health.

**Statement 3:** Dandruff is associated with an impaired epidermal barrier, leaving the scalp more prone to further fungal colonization, environmental pollutants, and inflammation. Individuals with dandruff have significantly reduced ceramides (EOS, NP), fatty acids, and cholesterol. The depleted and disorganized structural lipids may impact the barrier, as evidenced by elevated transepidermal water loss, subclinical inflammation, and higher susceptibility to topical irritants.

Dandruff is characterized by flaking and pruritus without any visible signs of inflammation, such as erythema.<sup>11</sup> The pathogenesis of dandruff is multifactorial, involving microbial colonization and intrinsic host factors such as sebum production.<sup>11</sup> There is evidence of changes in epidermal morphology in the scalp skin of dandruff sufferers, with reports of an increase in mean thickness and more

nucleated cell layers.<sup>11</sup> The increased epidermal thickness is not conducive to proper hair growth as the hair must pass through a thicker epidermis to reach the surface.

Dandruff may present with a deficient scalp barrier. Collins et al. demonstrated that in D/SD scalps, the scalp barrier was characterized by higher transepidermal water loss, diminished levels of total ceramides, global inflammation, and a greater susceptibility to topical irritants.<sup>12</sup> Analysis of scalp lipids showed a marked decrease in ceramides, notably ceramide 1, in dandruff-affected scalps and a total decrease in stratum corneum lipid species such as fatty acids and cholesterol.<sup>13,14</sup> Interestingly, males have also been shown to have 0.76 times lower ceramide levels and 1.4 times greater protein loss than females.<sup>12</sup> This impaired barrier makes dandruff sufferers increasingly susceptible to irritants, microbes, fungal colonization, inflammation, and pollutants that inevitably perpetuate and exacerbate the broken barrier.

**Statement 4:** A healthy stratum corneum forms a protective barrier to prevent water loss and maintain scalp hydration, protecting against external insults such as microorganisms and environmental triggers.

The stratum corneum has a multilayered structure that is frequently compared to a brick wall.<sup>15</sup> It consists of corneocytes embedded into a continuous lipid matrix formed by specialized barrier lipids.<sup>15</sup> Ceramides, cholesterol,

and fatty acids represent the main elements of the barrier lipids.<sup>15</sup> A healthy stratum corneum can protect the skin and body from water loss, external insults, and inflammation. Protecting the scalp skin from these aggressors is key to preserving homeostasis and preventing oxidative stress that would damage resultant hair. Disease, hormones, temperature, humidity, and surfactants affect the stratum corneum barrier function.<sup>15</sup> If the barrier is compromised, it can result in scalp dryness, itch, and dandruff.<sup>15</sup> In dandruff-affected scalps, studies have shown a dramatic depletion of barrier lipids and a poorly organized lipid layer, which provides little permeability barrier and allows the introduction of *Malassezia* and other microbes and toxins.<sup>15</sup> Thus, maintaining a healthy scalp barrier is key to protecting against exogenous insult.

**Statement 5:** *Improvement in scalp health has been shown to be able to reverse detrimental impacts on the hair by reducing oxidative stress and promoting a healthy scalp.*

Premature hair loss is primarily affected by the scalp environment in which it grows. Disturbed scalp conditions can perturb normal hair fiber maturation and firm fiber anchorage.<sup>10</sup> Oxidative stress produced by *Malassezia* species, ROS from exogenous sources, or a natural decline in antioxidant response due to chronological age or a disease state has been predominately accepted as the major disrupters of scalp health. Neutralizing this oxidative stress has been shown to reverse the detrimental impacts of ROS on the hair.<sup>10</sup> Multiple studies have demonstrated that reversing *Malassezia*-associated oxidative stress using zinc pyrithione shampoos results in healthier hair and reduced dandruff symptoms.<sup>13,16</sup> Antioxidants such as zinc, niacinamide, and caffeine have also demonstrated antioxidant properties that lead to barrier improvement and improved hair health.<sup>10</sup> Lastly, stratum corneum lipids in the scalp increase in dandruff patients treated with zinc pyrithione shampoo.<sup>13</sup> Decreasing oxidative stress in these patients improves barrier function, reduces symptoms, and leads to healthier scalps and improved hair appearance.<sup>13</sup>

## CONCLUSION

A healthy scalp and scalp barrier are required to protect from external insults and promote hair growth and retention. Oxidative stress is a significant driver of scalp barrier damage. ROS can lead to an impaired scalp barrier, resulting in dysfunctional hair growth and poor hair health. Scalp lipids, such as ceramides, are decreased in dandruff-affected scalps. Thus, reducing ROS and inflammation and maintaining a healthy scalp barrier may protect the scalp from further oxidative stress, promoting healthy hair.

## DISCLOSURES

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Contributing statement: All authors (MH, AA, NM, and HWL) contributed to developing the manuscript, reviewing this work, and agreeing with the content.

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# Etiology, Treatment Challenges, and the Role of Scalp and Haircare in Managing Dandruff

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## ABSTRACT

Dandruff and seborrheic dermatitis are associated with a disrupted scalp barrier that contributes to irritation, pruritus, and flaking of the scalp. The flaking and itch associated with dandruff can significantly impact an individual's self-esteem and quality of life. While the exact pathogenesis of dandruff is still not completely understood, scalp barrier health and its microbiome are thought to play significant roles in disease propagation. Five expert dermatologists with extensive experience in hair, dandruff, and seborrheic dermatitis were selected to participate in discussions that would result in five consensus statements focused on scalp barrier health and dandruff. Results of a systematic literature search and expert panel discussion are presented. These consensus statements aim to reflect expert opinions on the current understanding of scalp health in the context of dandruff and seborrheic dermatitis. The panel addressed challenges to promote scalp health, improve patient comfort, and prevent flares during dandruff management and maintenance. The presented consensus statements urge reframing our current understanding of dandruff and seborrheic dermatitis treatment by refocusing attention on global scalp and hair health.

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## INTRODUCTION

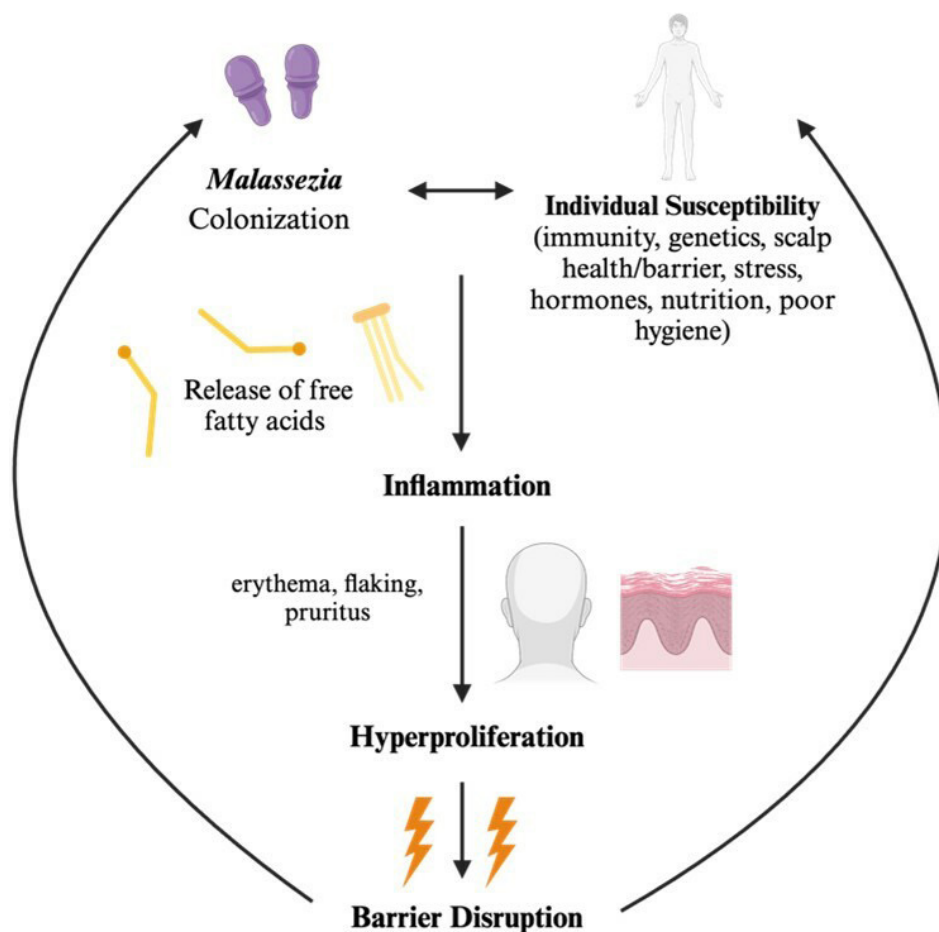
**D**andruff and seborrheic dermatitis (D/SD) affect about half of the general population worldwide.<sup>1</sup> SD in the scalp is commonly known as dandruff and is considered the same condition with varying degrees of severity.<sup>1</sup> Dandruff appears more prevalent among males, suggesting a potential androgenic component to pathogenesis.<sup>1,2</sup> D/SD commonly affects younger individuals between the ages of 18 and 24, with greater frequency in those over the age of 55 or under the age of 17.<sup>1</sup> Furthermore, SD occurs at a higher prevalence in immune-compromised populations, including patients with HIV/AIDs, neurological or psychiatric conditions (eg, Parkinson's disease, depression, brain and

spinal cord injuries) lymphoma, and organ transplant recipients.<sup>1</sup>

Dandruff is characterized by white and yellow flaking on the scalp and hair.<sup>1,3</sup> It can be associated with pruritus and irritation that may also be present on the forehead adjacent to the hairline, eyebrows, and retro-auricular areas.<sup>1</sup> An itchy scalp can significantly impair patient quality of life and may be detrimental to a person's self-esteem. It has been estimated that Americans spend \$300 million annually on over-the-counter (OTC) products to treat dandruff-associated flaking and scalp itching.<sup>3</sup>



**FIGURE 1. Seborrheic dermatitis and dandruff pathogenesis.** Multiple factors have been implicated in the pathogenesis of dandruff and seborrheic dermatitis. *Malassezia* yeast colonization in a susceptible individual (ie, with disrupted skin barriers) produces and releases irritating free fatty acids from sebum and subsequent inflammation, hyperproliferation of the stratum corneum, and further scalp barrier disruption. Disrupted scalp barriers make individuals more susceptible to microbes, itch, and further *Malassezia* colonization, further perpetuating the cycle. Figure made with Biorender.com.



While the underlying mechanism of dandruff and SD remains poorly understood, *Malassezia* is considered to play a role in D/SD pathogenesis.<sup>3</sup> *Malassezia* may trigger a multi-step inflammatory process of the scalp; lipases secreted by *Malassezia* leading to the release free fatty acids (FFA) such as oleic acid and lipid peroxides that may lead to inflammation; inflammatory cytokines such as interleukins IL-1 $\alpha$ , IL-1 $\beta$ , IL-2, IL-4, IL-6, IL-8, IL-10, IL-12, and tumor necrosis factor TNF- $\alpha$  stimulate keratinocyte proliferation and differentiation; and skin barrier breakdown leads to signs symptoms of flaking, pruritus, and erythema (Figure 1).<sup>4</sup> Treating dandruff with zinc pyrithione (ZPT), an antifungal agent, reduces the

inflammatory cytokines (IL-1 $\alpha$ , IL-8) and epidermal thickness, and improves epidermal barrier integrity markers (keratin 1, 10, 11) and stratum corneum lipids.<sup>5</sup> This suggests that antifungal treatments help to improve overall scalp health.<sup>5</sup>

Individual susceptibility and *Malassezia* colonization in a primed scalp create the ideal conditions for D/SD. Thus, repairing the conditions in which *Malassezia* species colonize is equally important as targeting the fungal component of the disease itself. This consensus paper presents five statements that provide insight into current literature and expert dermatologist consensus on D/SD and current treatment challenges for these conditions.

TABLE 1.

**Literature Search Objectives and Parameters**

**Scope:** Human studies investigating dandruff/seborrheic dermatitis, OTC skincare products for the scalp as adjuncts or monotherapy, and the role of topical ceramides containing scalp care products.

**Search Terms:**

Search Set 1: Dandruff/seborrheic dermatitis/contact dermatitis AND scalp condition OR scalp irritation OR premature hair loss OR prescription topical medication OR topical OTC treatment OR prevention OR shampoos OR leave-in treatment OR maintenance OR moisturizers

Search Set 2: Dandruff/seborrheic dermatitis/contact dermatitis AND ceramide-containing shampoo OR ceramide-containing scalp skincare OR ceramide-containing moisturizers for scalp care OR adjunctive scalp skincare OR education on scalp care OR adherence to treatment OR efficacy of scalp skincare OR safety of scalp skincare OR tolerability of scalp skincare OR skin irritation due to scalp skincare

**Included:** Randomized controlled trials, observational, cohort, and interventional studies, reviews, systematic reviews, guidelines, consensus, and pathways published in English from January 2010 to January 2024

**Excluded:** Publications outside the date range, preclinical studies not addressing skincare for dandruff/seborrheic dermatitis and publications in languages other than English

Over-the-counter (OTC)

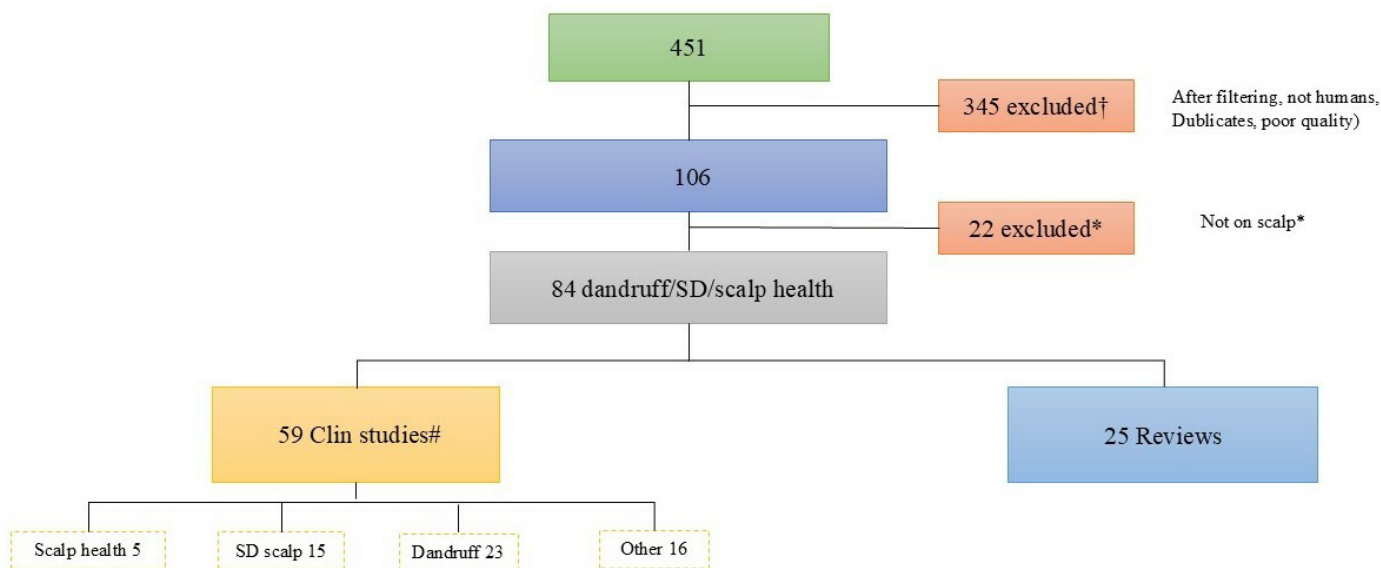
**METHODS**

This project was conducted in three phases: systematic literature review, development of consensus statements, and expert discussion and refinement of the consensus statements. A systematic literature review was conducted to inform the development of the consensus statements that would answer the question of what is currently known about D/SD. A structured literature search followed on January 29, 2024, to identify publications on D/SD, OTC skincare products as monotherapy or adjunctive therapy for these conditions, and the role of ceramide-containing scalp care products. Search terms can be found in Table 1. The search included English language publications from January 2010 to January 2024 and was conducted on PubMed and Google Scholar (secondary source) by a dermatologist and a physician/scientist as two independent reviewers. Publications identified through the search were graded for the type of study and the likelihood of changing confidence using the American Academy of Dermatology (AAD) evidence-based guideline development process.<sup>6</sup> A total of 59 clinical studies and 25 reviews met the quality and relevance criteria of the searches (Figure 2). The literature review objectives and parameters are summarized in Table 1. The project used a modified Delphi process comprising face-to-face discussions and an online follow-up to define 5 consensus statements that provide current expert perspectives on D/SD. Five expert dermatologists with experience in scalp, hair, and D/SD were selected to participate in this panel.

**RESULTS**

**Statement 1:** Scalp conditions such as dandruff have oxidative stress as a common etiology. Oxidative stress interferes with normal scalp keratinization and affects hair follicle and cuticle health.

Oxidative stress to the skin leads to unhealthy scalp conditions and has been associated with SD and dandruff.<sup>5</sup> Pre-emergent hair is intimately connected to the surrounding scalp tissue and may be negatively impacted by poor scalp condition, impacting hair quality.<sup>7</sup> Oxidative stress occurs naturally through age and interaction with our environment; however, increased levels of oxidative stress beyond that may be harmful. The skin has its defenses against oxidative stress known as superoxide dismutase (SOD), glutathione peroxidase (GP), and catalase (CAT) that neutralize ROS.<sup>7,8</sup> Malondialdehyde (MDA) and hydroxyoctadecadienoic acid (HODE) are indicators of lipid peroxidation and oxidation in the skin.<sup>8</sup> In SD, the levels of SOD, CAT, and MDA have been shown to be significantly increased compared to normal scalp skin.<sup>8</sup> It demonstrates a higher level of oxidative stress in these scalps with a greater requirement for antioxidant defenses.<sup>7</sup> In another study, HODE was found to be elevated in both the hair and scalp of SD patients, demonstrating the translation of oxidative agents from the pre-emergent to post-emergent hair environment.<sup>7</sup>

**FIGURE 2.** Structured literature search results.

†Google Scholar filtering is limited. \*Many scalp-related conditions come up as part of publications on AD, dandruff, and SD or as adverse events in clinical trials

\*No information was found on skincare as mono or adjunct to treatment. There were insufficient clinical studies found for grading

Used search terms are highlighted in Table 1: We identified 451 English-language articles. From these 451, 345 articles were excluded for irrelevance, and 22 were excluded for duplications. In total, 84 articles related to dandruff/seborrheic dermatitis and scalp health were included. Of the 84 articles, 59 were clinical studies, and 25 were reviews. Clinical studies were further stratified by studies on scalp health, seborrheic scalp, dandruff, and others.

Clin studies, clinical studies; SD, seborrheic dermatitis; RCT, randomized controlled trial

Oxidative stress in the scalp has been shown to significantly reduce the quality and retention of hair, which was shown to be reversible by treatment of the scalp with 1% ZP shampoo.<sup>9</sup> ZP reduced HODE and thereby oxidative stress of the scalp, likely through reduction of *Malassezia* species.<sup>7,9</sup> Applying antioxidant ingredients such as niacinamide, panthenol, and caffeine has demonstrated improvement in hair shedding, total hair count, hair quality, and overall scalp-skin barrier function in a clinical trial.<sup>10</sup> Thus, efficacious D/SD treatments should also target oxidative stress via antioxidant strategies to improve overall scalp health and resultant hair quality.

**Statement 2:** Dandruff is associated with an impaired scalp barrier, increasing the vulnerability to environmental pollutants, inflammation, and microbiome changes.

Scalp barrier dysfunction has been well-characterized in D/SD.<sup>2,5</sup> FFA and subsequent oxidative stress alone have been suggested to suffice for barrier breakdown and subsequent dandruff.<sup>8</sup> Oleic acid has been reported to induce flaking in the absence of *Malassezia* in certain individuals.<sup>8</sup> SD has also been shown to be associated with decreased ceramide levels in the scalp skin.<sup>8,10</sup> Dandruff-affected scalps show significantly reduced stratum corneum barrier lipids levels and increased transepidermal water loss (TEWL) compared to healthy scalps.<sup>11</sup> Dandruff sufferers also report a higher perception of pruritus when topical histamine is applied to the scalp.<sup>11</sup> This suggests an impaired stratum corneum and scalp barrier, which makes the scalp susceptible to environmental pollutants, increased TEWL, and increased inflammation.<sup>5</sup>

While *Malassezia* has been the predominant organism considered to lead to D/SD, newer theories have emerged that suggest that disequilibrium in the major bacterial and fungal populations may be more likely to lead to dandruff.<sup>12</sup>

*Propionibacterium* and *Staphylococcus* are the two predominant bacteria on the scalp, which negatively regulate one another.<sup>12,13</sup> There is decreased *Propionibacterium* and increased *Staphylococcus* on dandruff-affected scalps, suggesting that the balance between the two may be important in dandruff pathogenesis.<sup>12</sup> High water content and sebum production in the scalp provide ideal conditions for increased *Propionibacterium* growth.<sup>12</sup> Lin et al also observed these microbiome changes, finding that *Staphylococcus* and *Pseudomonas* could be potential biomarkers for SD.<sup>14</sup> Scalp barrier changes are associated with an increased risk of microbiome changes, inflammation, and further oxidative damage by environmental pollutants, exacerbating SD and dandruff.

**Statement 3:** *The scalp barrier may be disrupted by intrinsic factors (eg, disease) and/or extrinsic factors (eg, allergens, hair treatments).*

Various intrinsic and extrinsic environmental factors may impact the scalp barrier, which may put an individual at a higher risk of developing D/SD. Intrinsic factors include sex, hormone levels, sebaceous gland activity, skin lipid composition, immunity, and genetics.<sup>4</sup> Recent studies have shown that certain human leucocyte antigen (HLA) subtypes may confer a higher risk of D/SD development.<sup>4</sup> Male sex and higher androgen levels have also been associated with D/SD.<sup>2,11</sup> Androgens and adrenal corticosteroids stimulate sebum production, which is directly correlated to D/SD.<sup>4</sup> Increased sebum production provides more substrates for *Malassezia* lipases to act upon, resulting in increased toxic FFA secreted on the skin surface, suggesting that some individuals may have increased sensitivity to fatty acid-induced skin barrier disruption.<sup>4</sup> Individual immunity may also play a role in the scalp barrier and SD. This is suggested by the increased prevalence of SD in patients with HIV/AIDS, leukemia, lymphoma, and organ transplant recipients.<sup>1,4</sup> There is also evidence for neuroendocrine contribution, as many neurologic and psychiatric conditions such as Parkinson's disease, tardive dyskinesia, traumatic brain injury, epilepsy, spinal cord injury, and depression are associated with high rates of SD.<sup>1,4</sup>

Exogenous factors also contribute to scalp barrier integrity and D/SD, including an individual's scalp microbiome and microbial balance, life stressors, hygiene, hair practices, climate, medications, and diet.<sup>4</sup> Medications such as anticancer drugs, epidermal growth factor receptor (EGFR) inhibitors, and psychotropic medications such as haloperidol, lithium, and chlorpromazine have been associated with increased incidence of SD.<sup>4</sup> Common exogenous insults to hair and the scalp barrier include hair products containing bleach or formaldehyde and UV radiation.<sup>4</sup> These exogenous insults contribute to ROS on the scalp and contribute to barrier dysfunction that exacerbates D/SD.

**Statement 4:** *Reducing oxidative stress and promoting a healthy scalp barrier can reverse the detrimental effects of oxidative stress on scalp and hair health.*

Genetic intrinsic factors largely influence hair health in combination with exogenous factors such as hair care habits, treatments (physical and chemical), and overall scalp condition. Growing hair is susceptible to oxidative stress in its surrounding scalp environment.<sup>7</sup> Studies have shown that an unhealthy scalp can transmit negative growth signals to pre-emergent hair, which leads to premature hair loss and reduced hair follicle anchorages.<sup>9</sup> A study demonstrated that ZPT shampoo could reverse oxidative stress on the scalp and hair, leading hair to have lower moisture sorption and decreased water-wetting force, which was associated with stronger, shinier hair.<sup>9</sup> In another study, Kerr et al showed that treatment with ZPT shampoo improved overall scalp condition as measured by inflammation and barrier integrity.<sup>5</sup> Over three weeks, subjects using ZPT shampoo experienced a significant reduction in flaking, inflammatory markers, and improvement in markers of barrier integrity (keratin 1, 10, 11).<sup>9</sup> A reduction in oxidative stress and increased stratum corneum lipids such as ceramide and cholesterol in the scalp was also noted.<sup>9</sup> The application of antioxidant ingredients such as niacinamide and caffeine can also lead to improved hair fullness.<sup>10</sup> In a clinical trial, using these antioxidant ingredients in shampoo decreased scalp HODE and TEWL over 24 weeks.<sup>10</sup> These observations indicate that treating dandruff with antifungals, supporting scalp barrier function, and additional antioxidant ingredients targeting oxidative stress can lead to measurable differences in the scalp barrier and overall hair health.

**Statement 5:** *Most people suffering from dandruff use haircare products such as shampoos to manage their condition, although many have concerns about the lack of cosmetic elegance.*

The panel commented that although many OTC dandruff shampoos are effective, compliance may be lower due to the suboptimal cosmetic elegance of some products. (ie, most dermatologists/patients think the products work when using them, but compliance is low.)

Topical antifungals have been the gold standard and treatment of choice for D/SD.<sup>1,3</sup> Treatments for D/SD include ketoconazole shampoo, bifonazole shampoo, miconazole cream, ciclopirox olamine shampoo, selenium sulfide, and ZPT.<sup>1,3</sup> Reports of topical corticosteroid and topical calcineurin inhibitor use have also been reported.<sup>1,3</sup> However, despite treatments, D/SD often recurs or fails to adequately respond to treatment. In many cases, this can be linked to a lack of continued compliance due to an unfavorable washing experience or hair texture after washing. Due to dandruff's reoccurring, chronic nature, shampoo treatments must be used regularly. Counseling patients on regular use and more cosmetically elegant anti-dandruff haircare can help to promote compliance and outcomes.

Recent research has suggested D/SD as an inflammatory skin condition similar to atopic dermatitis and psoriasis. Pro-inflammatory cytokines IL-17 and IL-23 appear to promote *Malassezia*-induced inflammation, specifically in disrupted skin.<sup>16</sup> Wikramanayake et al also demonstrated high levels of IL-17 in an SD model.<sup>17</sup> Increasing research and understanding about SD and dandruff will lead to a growing arsenal of available treatment options that will appropriately target the pathogenesis of this condition for lasting, efficacious results in patients.

## CONCLUSION

D/SD, scalp health, and hair health are intimately related. D/SD treatment must address the symptoms and signs associated with dandruff, such as itch and flaking, as well as the root of the issue: scalp health, inflammation, scalp barrier disruption, and the long-term promotion of healthy hair and scalp. More research is needed to clarify the role of the scalp barrier and microbiome in dandruff and to identify clinically relevant ethnic variations in scalp microbiome composition to provide inclusive, culturally sensitive, and efficacious treatments to all dandruff sufferers.

## DISCLOSURES

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